WEAPON SYSTEM POLLUTION PREVENTION

MONITOR

Volume 4, Number 1 - Public Release Number 1196

November, 1996

CONTENTS

To be added to our mailing list, please write or call:
Human Systems Center (AFMC)
HSC/EMP
8213 14th Street, Bldg. 915
Brooks AFB, TX 78235-5246
Commercial: (210) 536-5452 / 3406
DSN 240-5452 / 3406
FAX (210) 536-3228 DSN 240-3228
E-Mail:
BIGGS@EMGATE.BROOKS.AF.MIL

FEATURE ARTICLE

TOXIC RELEASE INVENTORY (TRI) DATA FOR AIR FORCE MATERIEL COMMAND (AFMC) INDICATES A 30 % REDUCTION FROM 1994 BASELINE

The 1995 Toxic Release Inventory (TRI) data which was submitted by Air Force Materiel Command (AFMC) to USEPA, indicates that AFMC bases have made significant strides in reducing the use and release of TRI chemicals. Compared to the 1994 baseline, AFMC bases have achieved approximately a 30% reduction in TRI chemical releases (see Figure 1 below).

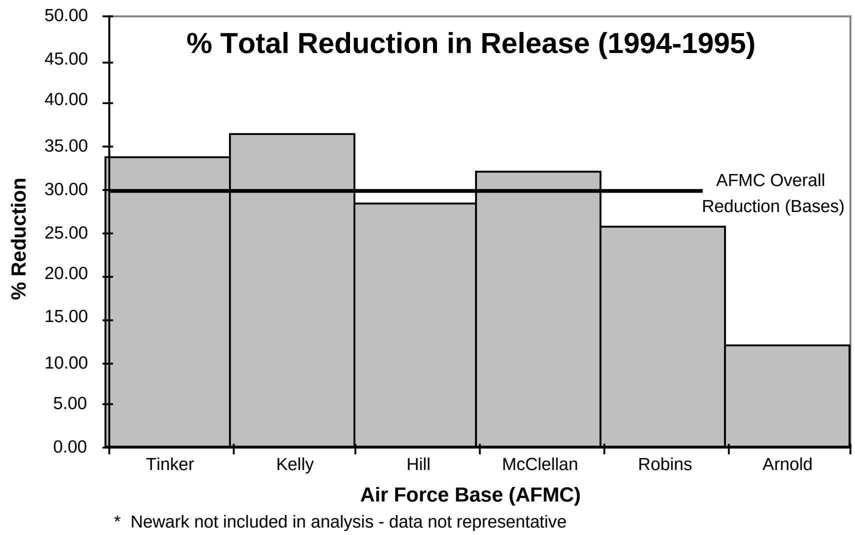

Figure 1

A “snapshot” of the contribution made by AFMC Bases and Government Owned Contractor Operated (GOCOs) sites to the 1995 TRI chemical release data is presented in Figure 2 (see page 2). In 1995, Tinker AFB, Robins AFB, and Air Force Plant (AFP) 6 contributed approximately 70% to AFMC’s total TRI chemical release.

Methylene Chloride, Methyl Ethyl Ketone (MEK), and Phenol were the three top TRI chemical releases for AFMC in 1995. Figure 3 (see page 2) summarizes the percentage contribution to these three chemical releases made by the top AFMC bases. Methylene chloride, the top TRI chemical for AFMC, has historically, been used in chemical-based strippers for aircraft removal applications. In the last few years, the Air Force has taken a systematic approach to promote the use of non chemical stripping pro-

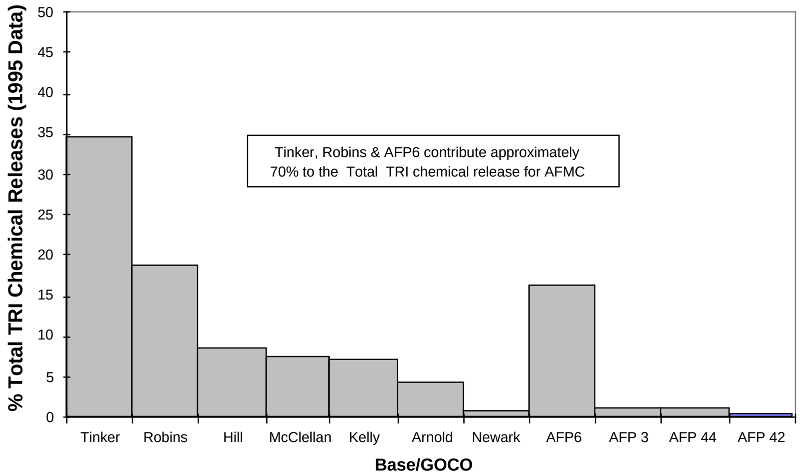

Figure 2

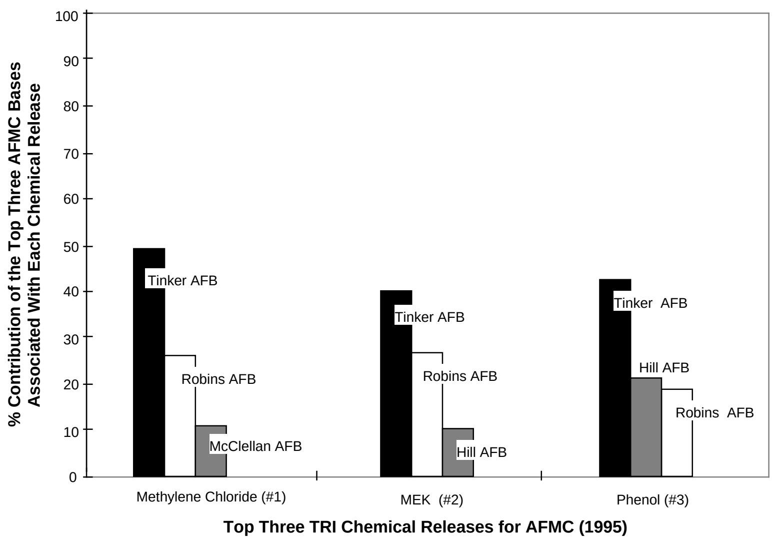

Figure 3

cesses such as Plastic Media Blasting (see related technology articles on pages 10 through 12). The use of these technologies has in part contributed to AFMC's success in achieving significant TRI chemical reduction.

For further information regarding AFMC's TRI data, please contact Mr. Milt Rindahl at DSN 787-7414. ❖

The Large Aircraft Robotic Paint Stripping (LARPS) program was initiated in 1991 as an Air Force Manufacturing Technology (MANTEC) project. This program is aimed at establishing an automated low-cost environmentally safe paint removal system for aircraft and aircraft components at OC-ALC. The program initially aimed at stripping thin skinned aircraft without damage, but has progressed to include the stripping of radomes and has developed into a joint initiative line item with the Navy to include ship and submarine coatings removal. The system is portable and includes a contaminant recovery system. It has demonstrated removal rates of 100 to 175 sq. ft. per hour. Information regarding the LARPS program is available from the Marketing and Management Support Office at WL-ALC (WL/DOR (513) 255-4119, refer to 95-11-4).❖

INFORMATION CROSS-FEED

AETC SHOP LEVEL POLLUTION PREVENTION TRAINING MANUAL

On 15 Oct. 1996, the Shop Level Pollution Prevention Training Manual was made available to AETC Logistics Environmental Coordinators. This training manual further empowers shop personnel "to take the next step" in the generation, development, and implementation of pollution prevention options.

This training encourages shop personnel to take ownership of pollution prevention projects by clearly defining the pollution prevention process from identification of opportunities to funding of projects. Participants are taught to work with appropriate AF personnel instead of depending on external organizations to perform work.

Training topics cover both universal pollution prevention and AETC base specific information. Universal topics include pollution prevention history, legislative authority, definition of pollution prevention, AF Environmental Organizational structures and goals, process for identifying existing and new options, detailed resource descriptions, a funding decision tree, and AETC's top pollution prevention options. Base specific information includes information on various functional areas, each complete with a flow diagram and descriptions of input materials, process operations, and wastes generated. Functional areas are comprised of shops that use similar materials and generate similar wastes.

The development of this manual was an AETC Command-wide project, and the results will benefit the Air Force in accomplishing its pollution prevention goals today and into the future. This training manual can be adopted and integrated into other command programs related to pollution prevention training.

HQ AETC/LG-EM has made this training manual available in an electronic version. Those interested in obtaining a copy, or require further information should contact Capt. Pat Woods or MSgt Ed Vogel at DSN 487-6850, or send their request by FAX, 487-6054. ❖

SUCCESS STORY: INITIATIVE TO LOWER PAINTING PROCESS COSTS FOR F-15 AIRCRAFT

Pollution Prevention Initiative

A suggestion was made to use Waterborne VOC Compliant 44-GN-36 Primer on all F-15 Aircraft in order to eliminate the required sanding operations.

Award Recognition

The success of this initiative is attributed primarily to:
- Mr. Terry Sewell (Team Leader)
- Mr. John DeAnoni (Team Coordinator)

Description of Existing Conditions

After the application of a primer to the F-15, the aircraft is usually sanded to ensure a smooth surface prior to the final topcoat application. Depending on the aircraft surface conditions after primer applications, sanding operations can require between 40-60 man-hours.

Implementation Details

The initiative was tested on the F-15 Saudi S-14 using the Deft 44-GN-36 Waterborne primer in place of the high solvent bearing MIL P23377 Type 1 primer. Additionally, the painting process was modified to eliminate sanding operations normally required.

The modified process required that shop level personnel be instructed on the use of 44-GN-36 as a primer on the F-15 aircraft. This initiative was reinforced through modifying process specifications to indicate that 44-GN-36 was the preferred primer.

Benefits & Cost Savings of Initiative

The modified procedure has:
- produced the best overall surface finish obtained on the F-15 aircraft.
- eliminated 40-60 man-hours of labor per aircraft and saved cost of materials associated with the process (e.g., sandpaper, cheese cloth and wipers).
- improved the work environment by eliminating chrome laden airborne dust generated during sanding operations.
- resulted in a cost savings of approximately $2,500 per F-15 aircraft.
- resulted in ~4 pound aircraft weight reduction.

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• resulted in a cost savings of approximately $2,500 per F-15 aircraft.
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This success story was submitted to the MONITOR by Mr. Paul Stifel (Contractor - MDA). For further information, please contact Mr. Stifel at (314) 232-1974.

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GENERAL VICCELLIO AUTHORIZES MODIFICATION OF AFMC POLICY DIRECTIVE 500-13

On September 1996, General Viccellio authorized the modification of AFMC Policy Directive 500-13 to include Environmental, Safety, and Occupational Health issues on Acquisition Strategy Panels (ASPs). In his letter, General Viccellio stated the modification to AFMC Policy Directive 500-13 ensures that AFMC aligns its efforts for non-major programs in accordance with the Defense Acquisition Board (DAB) efforts for major defense acquisition programs. The modification to AFMC Policy Directive 500-13 requires that ESOH experts are included on ASPs as well as other acquisition, maintenance, or modification focused integrated product teams.

For a copy of this signed letter, please contact Mr. Jay Carroll, HQ AFMC/DRMA at DSN 986-1732. ❖

ENVIRONMENTAL, SAFETY AND HEALTH (ESH) EVALUATION GUIDE FOR SINGLE MANAGERS UPDATE

DoD 5000.2-R requires that all programs, regardless of acquisition category, perform and maintain an Environmental, Safety and Health (ESH) evaluation. The evaluation consists of the following five analyses:

- National Environmental Policy Act
- Environmental Compliance
- System Safety and Health
- Hazardous Materials
- Pollution Prevention

The DoD 5000.2-R defines what must be included in the evaluation, but the method of implementation is left to the discretion of the Single Manager (SM). As such, there is a need for guidance to SMs. The ESH Evaluation Guide provides one approach and illustrates the risks, using actual program examples, of not focusing management attention on this critical issue.

The Guide discusses how the ESH evaluation is not just a piece of paper, but that it is the implementation of ESH considerations in day-to-day decisions within a program office. Approaches to institutionalizing ESH into the Weapon System Acquisition process within the existing Program Office organizational structure are identified. The Guide also discusses how the ESH thought process must be fully integrated into all program office documents, e.g., the Single Acquisition Management Plan, Request for Proposal and Test and Evaluation Master Plan.

1. Introduction and ESH Management
- Purpose and phase of the system
- ESH operations in the program

2. NEPA Status
- Summary of upcoming actions
- Status of NEPA documentation
- Assessment of risk

3. Environmental Compliance
- Evaluate compliance issues of the contractor
- Evaluate the compliance issues at the operation locations and primary depots
- Minimize cost, performance and schedule risks with respect to regulations

4. System Safety and Health
- Summarize system safety analysis issues
- Summarize health issues on the program

5. Hazardous Material Management
- Establish a hazardous material management program using NAS 411 as a guide
- Identify initiatives to reduce hazardous materials
- Ensure DoD incurs the lowest cost required to protect human health over the entire life-cycle

6. Pollution Prevention
- Summarize P2 program geared to eliminate pollutants in the weapon system to the maximum extent possible
- Summarize P2 initiatives of the contractor and the depot

7. Program Environmental Risk Summary and Conclusion
- Current risks in ESH, cost, schedule, and performance
- Anticipated future risks
- Risk mitigation

Figure 4. Outline of the ESH Evaluation Guide for Single Managers

The Guide presents a possible outline for the documenting the ESH Evaluation but indicates that tailoring should be accomplished based on the type of acquisition program and the development stage. The outline for the Guide is shown on Figure 4.

The ESH Evaluation Guide provides a roadmap for SMs to use in performing an evaluation of the environmental, safety and health considerations of their program. The appendix to the Guide will include applicable documentation and a Programmatic ESH Evaluation checklist to assist the SM in addressing ESH issues.

The Guide was coordinated throughout AFMC through the Acquisition Pollution Prevention Center Working Group and is designed to be periodically updated as necessary to keep up with current Air Force policy, as well as to include improvements. At the time of this writing the Guide is scheduled to be approved at the APPCWG meeting on 5 and 6 November 1996. Copies of the ESH Evaluation Guide for Single Managers are available from: ESC/AXEE; 5 Eglin Street; Hanscom AFB, MA 01731-2116; DSN 478-8127; or e-mail, langr@hanscom.af.mil. ❖

HSC/XRE AND WL/ML RELEASE NEEDS ASSESSMENT REPORT

The *Pollution Prevention Pillar Needs Assessment Report for FY 96* was released by the Materials Directorate of Wright Laboratory in July 96. The two-volume report summarizes the results of the P2 technology needs assessment completed by the Materials Directorate during the second quarter of Fiscal Year 1996. The report provides information on the alternative technologies with potential to solve the customer's needs. Volume One has seventeen separate chapters corresponding to the high priority P2 needs identified by the Environment, Safety, and Occupational Health (ESOH) Technical Planning Integrated Product Team (TPIPT). Chapter One provides an overview of the environmental, health and safety laws and regulations that may affect the selection of alternative materials and processes. Chapters 2 through 16 present an analysis of similar needs and available technologies to meet those needs. Chapter 17 offers a summary and conclusions of the needs analysis process and recommended approaches to meet unique needs within specific technology areas. Based on this framework, Wright Laboratory and the customer can develop a jointly supported funding strategy and establish a foundation for technology development and transition.

Volume Two, organized by customer site, presents an action plan for each Environment, Safety, and Occupational Health (ESOH) P2 need. Each action plan contains a description of the need, the objective in solving the need, and information on pertinent alternative technologies and R&D efforts. Further Details of the Needs Assessment Process and the report are provided below.

Needs Assessment Process

Wright Laboratory has developed a systematic approach to examine and respond to the pollution prevention needs of the Air Force customers. This approach is rather exciting because this is the first time the needs assessment process has identified potential commercial-off-the-shelf solutions to pollution prevention needs before new R&D programs are launched. In addition, the process helps to focus new R&D programs on the pollution prevention needs of the Air Force.

In the Fall of 1995, HSC/XRE identified and gathered pollution prevention needs across the Air Force. The ESOH TPIPT then reviewed, validated, and prioritized those pollution prevention needs. Next, an assessment team visited Air Force customers to discuss in greater detail the specific application for each technology need. The team included representatives from the Materials Directorate, other Wright Laboratory directorates, and support contractors. During these on-site visits, the team provided briefings to the customers on the Wright Laboratory Customer Focus Initiative and the assessment objectives. The objectives of the needs assessment process included the following:

- Defining short term customer needs that could potentially be met through commercial off-the-shelf technologies (COTS) and/or government off-the-shelf technologies (GOTS).
- Determining how to focus ongoing Air Force R&D projects to better address the customer's high priority needs.
- Planning and developing future R&D projects to meet the customer's need where COTS, GOTS, or on-going R&D projects are not available or suitable.

Figure 5 illustrates the Phase 2 subprocesses of the Technology Master Process (TMP). Phase 3 and 4 will involve development and execution of new R&D programs to meet customer needs where no COTS, GOTS, or on-going R&D programs are available. HSC/XRE completed Phase 1 by identifying the pollution prevention needs. WL/ML is completing Phase 2. Once the technical needs assessment process (Part 1) is complete, and a potential solution has been identified (Parts 2), Wright Laboratory will establish R&D projects to meet the appropriate high priority customer needs (Part 3).

Please contact Ms. Mary Ann Phillips at DSN 785-3929 for further information. The report is also located on the World Wide Web at http://www.wl.wpafb.af.mil. An example of the type of information contained in this report has been summarized in Tables 1 and 2 for metal plating needs and technologies. ❖

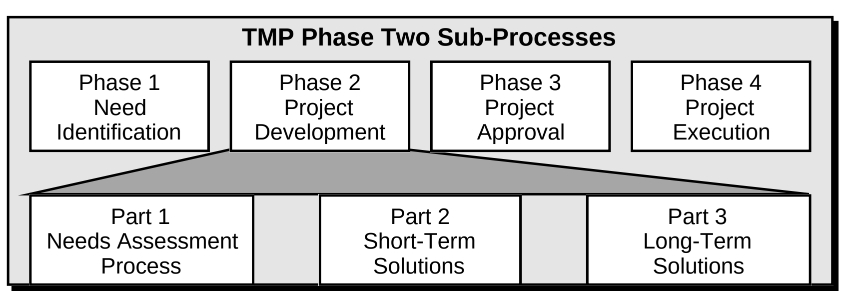

Figure 5. TMP Phase Two

Table 1. Overview of Plating and Surface Finishing Research Needs

Base	Pollution Prevention Needs	Description of Parts Being Plated	Existing Equipment	Recent Modifications
OO-ALC	**OO-ALC#227** • Identify nickel plating alternatives • Control nickel discharges to achieve discharge below regulatory limits	Landing gear components from the following aircraft: B-1, B-2, B-52, C-5, C-130, C-141, KC-135, F-4, F-15, F-16, T-38	Electroless nickel phosphorous baths - 2 baths containing 100 gals	None
	OO-ALC#238 • Identify cadmium plating alternatives • Control cadmium discharges to achieve discharge below regulatory limits	High strength steel landing gear parts for corrosion protection	Electrolytic nickel - 3 nickel sulfamate baths containing 2,500 gals; 1 nickel Woods strike bath containing 400 gals	Replaced cadmium plating with ion vapor deposited aluminum for 60% of the parts
	OO-ALC#228 • Identify chrome plating alternatives • Control cadmium discharges to achieve discharge below regulatory limits	Landing gear components from the following aircraft: B-1, B-2, B-52, C-5, C-130, C-141, KC-135, F-4, F-15, F-16, T-38	Hexavalent chromium is used; chromium source: chromatic acid	None
	OO-ALC#251 • Identify chrome plating alternatives	Landing gear components from the following aircraft: B-1, B-2, B-52, C-5, C-130, C-141, KC-135, F-4, F-15, F-16, T-38	Hexavalent chromium is used; chromium source: chromic acid	None
	OO-ALC#231 • Establish a representative test protocol to address hydrogen embrittlement testing for IVD aluminum coatings	Landing gear components from the following aircraft: B-1, B-2, B-52, C-5, C-130, C-141, KC-135, F-4, F-15, F-16, T-38	ASTM F519 hydrogen embrittlement test protocol	Draft 5 of ASTM F519 is being developed
SA-ALC	**SA-ALC#617** • Identify nickel plating alternatives • Control nickel discharges to achieve discharge below regulatory limits	F100 rear compressor drive shaft; TF39 Seal, #4 Air Bearing Sleeve; F100 Synchronization Ring; F100 Bleed Valve Carriage Guides	Electrolytic nickel plating - 3 watts nickel baths with a total 1,000 gal capacity; 2 nickel sulfamate baths with a total 840 gal capacity. Electroless nickel plating - NIKLAD 796 mid-range phosphorous with a 1900 gal capacity	Installed NIKLAD 796 equipment (electroless nickel bath) with continuous filtration in March 1996
	SA-ALC#618 • Identify cadmium plating alternatives	Threaded fasteners for the Allison T56 engines in C-130s	Cadmium uses sodium cyanide in the plating bath; cadmium cyanide plating bath, 1100 gal capacity	Working on cadmium plating replacement; either IVD Al or Zn-Ni plating
	SA-ALC#613 • Identify chromium plating alternatives • Control chromium discharges to achieve discharge below regulatory limits	Turbine engine components	Hexavalent chromium is used; chromium source: chromic acid; catalyst: sulfate acid anion. 4 chromium plating baths, total capacity 11,500 gal	Carrying out a $2.6M renovation of the chrome plating line to meet current NESHAPs requirements using advanced effluent treatment technologies
SM-ALC	**SM-ALC#526** • Identify non-cyanide silver plating alternatives • Identify technologies to decompose and remove cyanide in existing plating process	Miscellaneous job shop-type parts (e.g., microwave guides, electronic connectors, fasteners, and assembly/mounting hardware)	1 silver cyanide plating bath, 540 gal capacity	SM-ALC/TIME (J. Sanchez 916-643-5681) has been working on a non-cyanide silver plating process at the lab scale
WR-ALC	**WR-ALC#816** • Identify chrome plating alternatives • Explore proposed design changes to the M61A1 weapon system to eliminate need for chrome plating	M61A1 gun barrels found on fighter aircraft including the F-14, F-15, F-16, and F-18	Vendor equipment Saco Defense - Saco, ME	Work farmed out to Vendor, Saco Defense - Saco, ME

Table 2. Overview of Existing Pollution Prevention Technologies for Metal Plating

Technology Name	Needs Satisfied	Appropriate Metals	State of Development	Vendor
ALTERNATIVE DEPOSITION PROCESSES				
High Velocity Oxygen Fuel Metal Spray Coatings (HVOF)	Nickel or chrome plating alternative OO-ALC#227 SA-ALC#617 SA-ALC#613 OO-ALC#228 OO-ALC#251 WR-ALC#816 SM-ALC#526	 Nickel Nickel Chromium Chromium Chromium Chromium Silver	Commercially available and in use at OO-ALC	General Atomics San Diego, CA A. Gattuso (619) 455-2910
Other Thermal Spray Coatings for Nickel	Nickel plating alternative OO-ALC#227 SA-ALC#617	 Nickel Nickel	Commercially available	Stoody Doloro Stellite, Inc., Diamond Jet
Ion Vapor Deposition Aluminum Coating	Cadmium plating alternative SA-ALC#618 ASC#970	 Cadmium	Commercially available	
Ion Vapor Deposition Aluminum Coating	Cadmium plating alternative SA-ALC#618	 Cadmium	Commercially available	
MATERIAL SUBSTITUTES WITH WET CHEMICAL PROCESSING				
Zinc and Zinc Alloy Plating	Cadmium plating alternative SA-ALC#618 OO-ALC#238	 Cadmium	Commercially available	CorroBan™ Zinc-Nickel Plating
Tin and Tin Alloy Plating	Cadmium plating alternative SA-ALC#618	 Cadmium	Commercially available	
High Hardness Electroless Nickel	Chrome plating alternative SA-ALC#613 OO-ALC#228 OO-ALC#251 WR-ALC#816	 Chromium Chromium Chromium Chromium	Commercially available; one system already in place at SA-ALC	Allied-Chelite L. Galarza (210) 925-3190 SA-ALC, Amax Plating, Elgin, IL D. Anderson (847) 695-6100
Nickel-Tungsten-Silicon Carbide Plating (Takada Process)	Chrome plating alternative SA-ALC#613 OO-ALC#228 OO-ALC#251 WR-ALC#816	 Chromium Chromium Chromium Chromium	Commercially available; not qualified for government use	Preston, WA. N. Morris (206) 222-4544
Nickel-Tungsten Boron Plating	Chrome plating alternative SA-ALC#618 OO-ALC#228 OO-ALC#251 WR-ALC#816	 Chromium Chromium Chromium Chromium	Developed; commercial availability not known	Lawrence Livermore National Laboratory, Univ. California at Davis, and Amorphous Technologies International Laguna Niguel, CA J. Donaldson (714) 643-1700
ADVANCED BATH MAINTENANCE TECHNOLOGIES				
NIKLAD 796 Electroless Ni Process	Extend electroless Ni plating baths OO-ALC#227	 Nickel	Commercially available and in use at AFBs	MacDermid, Inc. Waterbury, CT. Mike Malik (810) 437-8161
ENFINITY Electroless Ni Process	Extend electroless Ni plating baths OO-ALC#227	 Nickel	Commercially available and tested at OC-ALC	Stapleton Technologies, Long Beach, CA Phil Stapleton (800) 266-0541
Effluent Treatment for Nickel Removal - Octolig™ System	Reduce effluent discharge OO-ALC#227 SA-ALC#617	 Nickel Nickel	Commercially available	Metre-General, Inc. Westminster, CO S. Sakr (303) 430-0095
Effluent Treatment for Cadmium Removal - Octolig™ System	Reduce effluent discharge OO-ALC#238	 Cadmium	Commercially available	Metre-General, Inc. Westminster, CO S. Sakr (303) 430-0095

SCIENCE AND TECHNOLOGY

CORROSION CONTROL IN THE AIR FORCE

This article is a follow up to the "Chemistry of Corrosion" article presented in the Sept. 1996 issue of the MONITOR.

What is corrosion?

Corrosion is commonly encountered as a deterioration of metal products as a result of chemical reactions with their environment. These reactions are driven by the tendency of metals to lose electrons and the tendency of oxygen to gain electrons. In electrochemical terms corrosion is a process where a metal anode loses electrons (oxidation) and a cathode where the electrons are taken up by oxygen or another compound (reduction) and the electrochemical circuit is closed by the travel of the ions from the cathode to the anode through an electrolyte (a conductive solution of salts). Therefore, corrosion is encouraged by the presence of water and salts that facilitate the transfer of ions. The anodic potential of metals varies from the highly anodic magnesium through aluminum, zinc, chromium, iron, cadmium to the least anodic nickel, lead, copper, and silver. Placement of one metal in contact with another induces corrosion of the more anodic metal.

Corrosion requires the following conditions to be present: 1. Exposure to oxidizing materials (oxygen and acids). 2. Closure of the external electrochemical circuit (by conductive water and salts - electrolytes) 3. Some locations on the metal structure capable of becoming anodes. 4. The absence of a passivating layer of corrosion reaction products (passivation is the formation of an impervious, stable, insoluble barrier to corrosive attack by metal oxide corrosion products).

How corrosion is avoided?

To eliminate corrosion at least one of the above conditions for corrosion must be eliminated. Paint and other low permeability organic coatings separate the metal from its environment. In addition, coatings of noble metals or less corrodable metals such as chrome or nickel, that form passivating oxide layers, provide a coating with good mechanical properties while providing the required physical barrier between the metal and its environment. Corrosion may also be stopped by preventing the protected metal part from becoming an anode. This may be accomplished by contacting it with a more anodic metal that is sacrificed to corrosion (the protected metal becomes a cathode) or providing an electric potential that forces the protected metal to become a cathode. Some metals (e.g., aluminum, nickel and chrome) produce passivating oxide layers that both seal the metal surface from additional contact with the corrosive environment and prevent corrosion by the presence of corrosion products.

Using paint to avoid corrosion requires the use of a pretreatment or primer which contains metals that are more anodic than the base metal. The more anodic particles protect the part surface from corrosion by sacrificial anodic (galvanic) protection. The paint seals the surface and limits moisture and oxygen reaching the steel. Current primers often contain hexavalent chromium compounds because they are very anodic and because they form chemically inert chrome oxides (trivalent chromium). Paint requires periodic reapplication to maintain its corrosion protection and aesthetic qualities. In preparation the paint and primer are removed (depainting) before repainting without damage to the metal substrate. During the process of depainting the paint and the primer typically are removed by a stripping solution of aggressive chemicals. The chemicals may attack the substrate surface, but this may be prevented by adding inhibitors such as chromate salts. A discussion of the use of chromium chemicals and coatings for corrosion prevention are further discussed in the article titled "Overview of the Air Force/DoD Chromium Elimination Program." ❖

COATING REFORMULATIONS in particular have received a great deal of attention. Over the past several years, manufacturers of aerospace coatings have reformulated primers and topcoats to reduce the VOC content of the materials. Currently, several suppliers have qualified waterborne primers, high solids primers, and high solids topcoats. Primers are now formulated with a maximum VOC content of 2.8 lb/gal, while the standard for topcoats is 3.5 lb/gal. While these formulations are consistent with the Aerospace National Emission Standard for Hazardous Air Pollutants (NESHAP), there is still a push to drive emissions of HAPs and VOCs to the lowest possible level. There now exist qualified polyurethane coatings under MIL-C-85285 that have a VOC content of 2.8 lb/gal. The spec requirement is 3.5 lb/gal. One advantage offered by the lower VOC topcoats is that adequate film thickness can often be achieved in one pass. This is primarily a function of the higher solids content of the coating. ❖

OVERVIEW OF THE AIR FORCE/DOD CHROMIUM ELIMINATION PROGRAM

Chromium chemicals and coatings are used in many the aspects of corrosion prevention:
- Plating for appearance over a corrosion resistant coating.
- Plating for hardness and resistance to erosive wear.
- Conversion coatings on aluminum, steel and other metals.
- Pigments and inhibitors in primers, sealants and waxes.
- Corrosion inhibitors in paint stripping and pickling.
- Anodizing, typically of aluminum.

Metallic chromium and its oxide are quite inert. Hexavalent chromium, the active form of chromium used in plating, chromic acid etching, anodizing and corrosion inhibition in primers and paint strippers, is a carcinogen and causes significant damage over extended release periods in the environment even at low concentrations.

In the use of hexavalent chromium in plating, anodizing, and etching baths minute droplets of solution are released into the air causing significant occupational risk. Depainting operations are labor intensive and are conducted with hexavalent chromium rich stripper solutions sprayed onto the parts. The occupational dangers are significant because this process results in dripping, formation of pools on the floor, and mist in the air.

In order to prevent emissions of chromium into the environment, various systems are used to eliminate the chromium from the emissions and/or waste streams in the metal finishing facilities and in the industrial waste water treatment plants. The process operation adds to the cost and the resulting sludge is classified as hazardous by the EPA source rule and is disposed in hazardous waste dumps at some expense.

Minimizing Chrome Pollution

Hexavalent chromium pollution and occupational hazards may be reduced or eliminated by a number of methods. Some elimination/reduction methods include: recycling of hexavalent chrome from paint stripping and Alodine process, extending hard chromium plating bath life by control of bath chemistry, better control of entrainment above the bath, replacement of chrome plated coatings with other materials, and elimination of chrome based corrosion inhibitors in depainting solutions for new coatings.

Chromium electroplate coatings may be eliminated altogether by the use of newer coating deposition techniques that have been developed for similar applications. The requirements/advantages of alternative coating processes are summarized in Table 3 (see page 10).

DoD and Air Force Cr^{+6} Elimination Projects

The Air Force projects coincide with the DoD initiative to eliminate use of chromium plating in coating systems. The DoD pollution prevention effort includes the Environmental Security Technology Certification Program (ESTCP) that is managed by the Deputy Under Secretary of Defense for Environmental Security. These projects focus on coating deposition to form hard coatings and to form corrosion protection coatings for non-wearing elements on steel and aluminum (including IVD aluminum coating). Targets include all chrome plating uses in Army, Navy and Air Force.

The central technologies of interest for the ESTCP project are high energy vapor and ion deposition techniques. Also of interest are chrome replacement in conversion coating and surface pretreatment. The National Defense Center for Environmental Excellence (NDCEE, http://www.ndcee.ctc.com/) has constructed a chromium technology testing and demonstration facility operated by Concurrent Technologies Corporation (CTC, http://www.ctc.com/). The center has the following processes available for demonstration:

- Plasma spray
- HVOF,
- brush plating,
- laboratory electroplate systems,
- closed loop electroplate,
- ion plating,
- ion beam assisted physical chemical vapor deposition, and
- spray casting.

The major chrome replacement technology projects currently underway are intended to replace chromium coating, etching, and anodization. The major DoD research and development efforts are complemented by some EPA and industry funded research. Some of the investigators and projects are given in Table 4 (see page 11). ❖

Table 3. Requirements for Chromium Replacements in Coatings

Coating System Component	Requirements/Advantages
Surface preparation	➡ Minimal change from current process ➡ Minimal cost ➡ Environmentally friendly ➡ Simple to operate and better occupational safety
Coating deposition	➡ Environmentally friendly (minimal waste, preferably no plating solutions) ➡ Simple to operate and better occupational safety ➡ Established technology
Coating Performance	➡ Mechanical and surface properties as good or better than chrome plate (wear resistance, hardness, adhesion etc.) ➡ Longer life (prevent or delay stripping) ➡ Corrosion resistance as good or better than chrome plate
Stripping (Repair)	➡ Requires minimal use of chromates, acids, bases ➡ Stripping product recyclable for minimal waste - environmentally friendly

CHEMICAL STRIPPING AGENT REPLACEMENT TECHNOLOGIES

Paint removal operations at maintenance depots are major contributors to hazardous waste generation in the DoD. The primary chemical stripping agents currently in use at the various ALC's include methylene chloride, and phenol-based compounds, with methylene chloride being the most prevalent chemical in use. Over the past several years, various companies have developed paint strippers to replace methylene chloride as a "drop in" solution. The majority of these strippers contain benzyl alcohol. Both alkaline/amine and acid activated strippers have also been formulated. The acid activated strippers have been successfully used in the commercial sector; however, these strippers are not considered to be acceptable for military applications because of their potential to induce hydrogen embrittlement in high strength steel.

The most commonly employed replacement strategy involves physical removal techniques such as particulate and high pressure water blasting. It has been suggested that for every paint removal application, a blasting medium process exists that is superior to any solvent system. Of these, Plastic Media Blasting (PMB) using Type V plastic is the most widely used.

Compared to chemical strippers, the waste reductions using Type V media are dramatic. For example, stripping a single F-15 aircraft resulted in the production of over 6,600 pounds of water/methylene chloride waste; depainting a similar aircraft using PMB generates only 183 pounds of wastes.

Figure 6 shows several of the Air Logistic Centers that employ PMB. In addition to the noted aircraft, most depaint parts from other airplanes as well as aircraft ground equipment. Although PMB depainting operations have achieved dramatic reductions in the production of stripping wastes, large quantities of spent media waste are generated. For example, SM-ALC generates from 300,000 to 500,000 pounds of spent media per year.

Base	Planes Depainted with Type V Media
WR-ALC	F-15
OC-ALC	B-4, B-52
OO-ALC	F-16
SA-ALC	C-5
SM-ALC	F-15, A-10, F-111

Figure 6.

An advantage to the PMB process is that it can be recycled by passing the spent media through a reclamation system that consists of a cyclone centrifuge, a dual adjustable air wash, multiple vibrating classifier screen decks, and a magnetic separator. In addition, some manufacturers provide dense particle separators as a reclamation system. The denser particles, such as paint chips, are separated from the reusable blast media, and the reusable material is returned to the blast pot. Typically, media can be recycled 10 to 12 times before they become too small to remove paint effectively. ***(Continued on Page 12)***

Table 4. Chrome Technology Investigators

Technology	Evaluation Results	Investigator/Client
HVOF	Coating is much harder and wear resistant than electroplate chrome. Process window is wide.	BIRL, Northwestern U. Keith Legg, George Nichols T 708 467 1572 F 708 467 1022 MITRE Neil Sylvestre T 703 883 5708 F 703 883 1951 Concurrent Technologies Corporation, David S. Viszlay T 814 269 2593 F 814 269 2798 Some work is conducted from SM-ALC. (McLellan AFB), NDCEE and commercial clients
PSII	Coating is much harder than electroplate chrome when used on chrome and steel.	Los Alamos National laboratory, (LANL) Jay T. Scheur T 505 665 6525 F 505 665 3552 For US Dept. of Energy, and US Dept. of Commerce
CAPVD CCAD	Coating is almost as hard as chrome and wears as well or almost as well as.	Implant Sciences Corp. A. J. Armini T 617 246 0700 F 617 246 1167 For US EPA
IBAD	Coating (after nitride implantation) is much harder than chrome electroplate. Low deposition rate. Only thin coating and nitride are energy efficient. Use in combination with CAPVD/CCAD.	Implant Sciences Corp. A. J. Armini T 617 246 0700 F 617 246 1167 For US EPA (Cr), US Army (diamond), US Air Force (SiC) (N+ impregnation): Southwestern Research Institute, Dr. James H. T 210 522 6588 F 210 522 6965 and Oak Ridge National Laboratory, J.M. Williams T 423 574 6265 F 423 576 8135
EB-PVD and Laser cladding	High deposition rate of EB-PVD and Laser cladding.	Applied Research Laboratory, Penn. State Prof. Jogender Singh T 814 863 9898 F 814 863 1183 Concurrent Technologies Corporation, David S. Viszlay T 814 269 2593 F 814 269 2798
Thermal deposition	High hardness (Cr_2O_3 in particular), wear reduced by 1/3 factor (for WC). Corrosion resistance is much improved with WC-Cr and Cr_2O_3 (no pitting) and resistance to 50% HCl.	Sikorsky Aircraft, Robert Guillemette T 203 386 7559 F 203 386 7523 For US Army
"Takada" Ni-W-SiC electroplate	Coating is as hard as electroplate chrome.	MITRE Neil Sylvestre T 703 883 5708 F 703 883 1951
AMPLATE Ni-W-B Cemkote® NiB Electroplating	Coating is as hard as electroplate chrome. NiB applied for automotive and plastic molding tools and some aerospace approvals.	U. of California, Davis, Prof. Ahmet N. Palazoglu T 916 752 8774 F 916 752 1031 Lawrence Livermore National Laboratory, Sandia National Laboratory National Chemical Corporation, Edward McComas T 407 223 4058
Very Hard Electroless Nickel	Coating is close in hardness to electroplate chrome. Wear tests show less wear resistance than chrome electroplate.	McGean-Rohco, Inc., OH D. Kent Dickie T 216 441 4900 X-3010, F 216 441 1377
Manganese Silicate for Aluminum	Coating is as resistant to corrosion as chrome electroplate (on bulk aluminum).	McDonald-Douglas, Inc. Sanchem, Inc., Dr. John W. Bibber T 312 733 6100, F 312 733 7432
Spray Casting Ni Alloy	Coating parameters can be used to control hardness and corrosion resistance	MSE Technology Applications, Ronald J. Glovan T 312 733 6100, F 312 733 7432
Sol-Gel preparation of bonding surface and silane surface pretreatment	Sol gel coating is similar to Anodine in adhesive: bond or paint.	Sol-Gel: Chemat Technology Inc., Su-Jen Ting T 818 727 9786 F 818 727 9477 For Air Force U. of Cincinnati, Prof. Wim J. Van Ooij T 513 556 3194 F 513 556 2569 For EPA
Alternative anodizing and etching by sodium hydroxide with or without hydrogen peroxide	Results are similar to those of chromate based etchings but require additional development	Concurrent Technologies Corporation, David S. Viszlay, T 818 727 9786 F 818 727 9477 For ARDEC

(Chemical Stripping continued from Page 10)

The environmental advantages of PMB can be substantial. PMB can reduce hazardous chemical paint stripper waste by approximately 50 percent. Another important advantage is that PMB may be used at much lower pressures than conventional media. PMB is well suited for stripping paints on selected aircraft since the low pressure and relatively soft plastic medium have minimal effect on the surfaces under the paint. A notable exception is the KC-135 - it cannot be stripped via PMB - a more conventional stripping method must be utilized. Furthermore, by selecting the appropriate media hardness, plastic particles can remove surface coatings while leaving harder undercoatings intact. ❖

SM-ALC DEVELOPS A PROCESS TO REFORMULATE SPENT MEDIA FROM DEPAINTING OPERATIONS

There are currently three methods for dealing with the waste from the plastic media blasting operations. The first is disposal in a Type III hazardous waste landfill. This is both an expensive and unattractive option from a Pollution Prevention viewpoint. The second alternative is to lease the plastic media from the supplier; after use the spent media is returned as hazardous material (not hazardous waste) to the supplier for alternative uses. Some suppliers use the returned spent media as filler in the construction of bathtubs, sinks, etc. This is an attractive option, but the extra cost for leasing the media results in a significant mark up over the media purchase price. This option is being utilized by several bases. It has the advantage of reclassifying the hazardous spent media waste as a hazardous material and technically eliminating the production of hazardous wastes from the PMB operation.

A third option may soon be available. SM-ALC is developing a process to reformulate the spent media back into useful media for reuse in the PMB process. A full-scale prototype plant has been constructed at the McClellan AFB (Sacramento, CA). The facility, while still in the startup phase, is successfully reformulating spent Type V plastic dust from the aircraft depainting operations into media. If successfully implemented, this option should have several advantages. First, it would reduce the generation of hazardous PMB wastes, and their associated disposal costs. Second, it would reduce the requirements for new media, and the associated new-media purchase costs. Third it would reduce the RCRA cradle-to-grave control concerns with the media-lease option.

The heart of the process is an extrusion system that transforms the spent media into a viscous liquid using a plasticizing agent. This liquid exits the extruder as spaghetti-like strands which are chopped into small pellets, dried (to recover the plasticizer), and ground to size. Initial testing has shown that the recycled media is an effective paint remover.

For further information regarding the PMB waste reformulation and reuse process, please contact Steve Mayer at DSN 633-2517 ext 320 at McClellan AFB. ❖

HALON 1301 REPLACEMENT IN DOD AND COMMERCIAL APPLICATIONS

Extinguishing a fire in a confined space requires reduction of the oxygen concentration in proximity to the burning fuel to a level at which the fire is extinguished. This application is referred to as total flooding. The fire extinguishing material of choice for this application over the past twenty years has been Halon 1301 (bromotrifluoromethane, CF_3Br). Halon 1301 may be stored at moderate pressures as liquid, and it evaporates readily when its container is opened to atmospheric pressure thus making it an ideal total flooding agent. Furthermore, the chemical reactions of Halon in fires cool down the fuel and serve to reduce the quantity of extinguishing gas needed to suppress the fire. Halon 1301 is non toxic, non corrosive and non conductive and can be used in occupied areas and on sensitive electronics. The chemical reactions that make Halon 1301 attractive as a fire fighting agent also cause it to deplete ozone at 10 to 40 times the rate of CFCs. Because of this characteristic, its production has been banned and no additional quantities will be available to replace Halon 1301 when it is used. The search for Halon 1301 replacements has focused on gasses that may be used for total flooding fire suppression.

The minimum concentration of Halon 1301 required for fire suppression is about 6% whereas all the alternative fire suppressants currently evaluated for DoD or commercial uses require concentrations of at least 10 to 12% (C3 and C4 CFCs, HFC-227, HFC-125 and HFC 23) and up to 30 to 50% (CO_2 and Inergen). The more effective CFCs and HFCs compositions are either moderate ozone depleting substances, or strong greenhouse gasses that the EPA prefers to avoid.

The EPA developed the SNAP program for matching Halon 1301 replacements with their best applications. A summary of the recommendations is given in Table 5. The recommended chemicals were evaluated for their effectiveness and toxicity in various applications by DoD and the Air Force, Navy and Army as well as by commercial organizations. The Navy has produced a shore facilities in its ODS Conversion Guide available online at < http://www.ncts.navy.mil/homepages/navfac_es/shoreg2.htm>.

The limitations of space and weight in existing aircraft, ships and tanks do not allow for an increase in the volume of agent. Since all the alternative agents require at least doubling the quantity of material, it is not possible to retrofit most critical systems. Extinguishing highly flammable fuel mist may not be effective with some Halon 1301 alternatives because it may not be possible to apply the extra quantities of agent that are needed to suppress the flame. The materials closest to the low toxicity and high effectiveness of Halon 1301 are C3 and C4 CFCs, but they are greenhouse gasses and their use will require EPA permitting. Most of the effective HCFCs are toxic at their effective concentrations and, therefore, cannot be used in occupied areas.

Table 5. SNAP Halon 1301 Replacement Substitution Recommendations

Substitute	SNAP Recommendation
Powered Aerosol C	Acceptable
Water Mist Systems using Potable or Natural Sea Water	Acceptable
(Foam) A (formerly identified as Water Mist Surfactant Blend A)	Acceptable
HCFC-22B1	Unoccupied areas, Ozone depletor
HCFC-22	Unoccupied areas, Ozone depletor
HCFC-124	Unoccupied areas, Ozone depletor
(HCFC Blend) A	Acceptable, Ozone depletor
HFC-23	Acceptable, Ozone depletor
HFC-125	Unoccupied areas, Ozone depletor
HFC-134a	Unoccupied areas, Ozone depletor
HFC-227ea	Acceptable, Ozone depletor
C_3F_8, C_4F_{10}	Greenhouse gas, use only where physical and chemical properties and its low toxicity make alternatives technically infeasible
CF_3I	Acceptable, unoccupied areas
IG-01, IG-55, IG-541 Inert Gas Blends	Acceptable
IG-541	Acceptable
Gelled Halocarbon/Dry Chemical Suspension	Unoccupied areas
Inert Gas/Powdered Aerosol Blend	Unoccupied areas
Carbon Dioxide	Acceptable
Water Sprinklers	Acceptable

(Some materials are still being tested for toxicity and should be used only when OSHA guidelines are established.)

The Halon 1301 replacements under study, or used in DoD and commercial applications are given in Table 6 (see page 14). They are listed according to the military department investigating them. In addition to these applications, simulators of Halon 1301 are needed for training and discharge system testing (for certification) that is responsible for almost 70% of all DoD Halon 1301 emissions. Sulfur hexafluoride is being investigated as a Halon 1301 simulant for a variety of discharge testing and it may be used for training as well. ❖

Table 6. Halon 1301 Replacements in DoD and Commercial Applications

Fire Suppressant Alternative	United States Air Force	United States Navy	United States Army	Commercial Sector
HFC-125 (FE-25, etc.)	Under evaluation for F-22 Fighter Aircraft (engine nacelles and dry bay)			
HFC-227ea (FM-200)		Approved Halon alternative for occupied spaces. New ship production in conjunction with fine water mist. Computer facilities, fuel and oil sites	Watercraft engines in conjunction with sprinklers, in hydraulic rooms	Commercial shipping and computer facilities
Inert Gas Generation Technology	Under evaluation for F-22 Fighter Aircraft (engine nacelles)	Specified for initial production of F/A-18E/F fighters (engine nacelles and dry bay) and V-22 Osprey (dry bay)		
Dry Powder Aerosols (Powdered Aerosols A, B, C, etc.)	Under evaluation for computer facilities and as fire fighting devices		Under evaluation along with halocarbons for use in ground combat vehicles (crew and engine compartments)	
HFC-236fa (FE-36)			Under evaluation for use in ground combat vehicles (crew and engine compartments)	
HFC-23 (FE-13, 23)		Approved for occupied and unoccupied areas where sprinklers cannot be used		Flammable liquid processing and storage areas, turbine enclosures
Inergen (52% nitrogen, 40% argon, 8% carbon dioxide)		Approved for unoccupied areas. Computer room subfloor space		In use for information storage areas
CEA-410 (C_4F_{10}) (perfluorocarbon)				Telecommunication installations, electronics, control facilities, etc.
Trifluoroiodomethane (CF_3I)				Under evaluation for telecommunication installations, electronic switchboard rooms etc. (unoccupied areas only)
Carbon Dioxide	In use on the flight line		Evaluated for replacement in portable handheld extinguishers and vehicle engine compartments	
Water Sprinklers	Computer facilities (PC only)	Replacement in all non-dry facilities (not with flammable chemicals or valuable/ critical electronics)	Computer facilities (PC only)	In use for residential and office fire suppression

U. S. ARMY PROVIDES GUIDANCE FOR ELIMINATING CADMIUM

Cadmium because of the health risks associated with its use is high on the elimination priority list for DoD. The U. S. Army Acquisition Pollution Prevention Support Office (AAPPSO) provides an April 96 publication, "**Guidance for Eliminating Cadmium from U. S. Army Weapon Systems**" which addresses the health impacts, economic ramifications, elimination approaches, and provides technical guidance to assist in the elimination of cadmium. The publication features a series of flow charts designed to assist in the alternative selection process. This is an engineering approach based on actual experimental conditions in evaluating alternatives to be used for specific applications such as on fasteners and other hardware.

To obtain a copy of this publication, write or call Mr. Mike Kisner, Ocean City Research Corp., 4805-B Eisenhower Ave. Suite 5, Alexandria, VA 22310, TN (703) 212-9006. For additional information, contact Mr. George Terrell of AAPPSO at (703) 617-9488 or e-mail: <gterrell@hqamc.army.af.mil>. ❖

Halon Web Site Description

- U.S. Army Environmental Center (USAEC): http://aec-www.apgea.army.mil:8080/index.html
- Navy CFC & Halon 1301 Clearinghouse: http://home.navisoft.com/navyozone/index.htm
- Naval Facilities Engineering Command (NAVFACENGCOM) http://www.ncts.navy.mil/homepages/navfac_es/
  - Shore Facilities Ozone Depleting Substance Conversion Guide
  - Environmental Laws and Regulations
  - PR-99 Environmental Requirements Cookbook
- HARC http://www.halon.org/halonalt.html
- Halon information can be found at: http://www.brooks.af.mil/
- To search mil specs and other DoD databases: http://www.dtic.mil/stinet/public-stinet/all/multi_all.html:

THE MONITOR ON INTERNET

The Weapon System Pollution Prevention MONITOR is now available on the Internet. Issues will be placed on the net about one week after publication. The newsletter can be accessed via the HSC/EMP Home Page at http://www.brooks.af.mil/HSC/EMP/emp-home.htm. Any World Wide Web browser (e.g., MOSAIC) can be used to view or download newsletter issues. All internet sites listed in this publication can be accessed through the MONITOR directly.

UPCOMING EVENTS

Date	Meeting	Location	POC	Phone/Fax
	JG-APP Initiative (now on the internet)	http://www.jgapp.com/	Mr. Larry Fry	DSN 785-3059 ext. 334
05-07 Nov 96	Acquisition P2 Center Working Group Conference - 5th Joint Solutions to Common Problems	WPAFB, Area B, C-17 Conference Room	Mr. Perry Beaver	DSN 785-3059 ext. 317 FAX DSN 785-4155
12 Nov 96	ASC Acquisition P2 Environmental Protection Committee Meeting	WPAFB, Bldg 32, 1330-1500 (tentative)	Maj. Issac Atkins	DSN 785-3059 ext. 343
17-20 Nov 96	The National Fire Protection Agency (NFPA) Fall Meeting	Opryland Hotel Nashville, TN	NFPA	(617) 984-7310
20-22 Nov 96	Clean Air '96	Orlando, FL	Air & Waste Management Assoc.	(412) 232-3444
02-04 Dec 96	ISO 14000 Conference	Washington, DC	Executive Enterprises	(800) 831-8333 FAX (800) 250-3861
03-06 Dec 96	7th Annual International Solvent Substitution Workshop	Pointe Tapatio Cliffs, Phoenix, AZ	Ms. Eileen Schmitz	(847) 234-2353
04 Dec 96	Acquisition P2 Center Working Group VTC	1030-1130 Eastern Time	Maj. Bob Lang	DSN 478-8127
03 Jan 97	Acquisition P2 Center Working Group VTC	1100-1200 Eastern Time	Maj. Bob Lang	DSN 478-8127
27-30 Jan 97	Hazardous Materials and Waste Management Conference and Exhibition	Portland Hilton, Portland, OR	Ms. Lynne Holden, ADPA	(703) 522-1820 FAX (703) 522-1885
04-06 Feb 97	Acquisition P2 Center Working Group Conf. - 6th Joint Solutions to Common Problems	AFFTC, Edwards AFB, CA	Capt. Saroya Follender	DSN 527-1433 FAX DSN 527-6145

HSC/EMP
Building 915
8213 14th St.
Brooks AFB, TX 78235-5120